METHOD AND APPARATUS FOR SELECTIVELY PROVIDING DIFFERENT ELECTRIC SIGNAL PATHS BETWEEN CIRCUITS

BACKGROUND OF THE INVENTION

[0001]

This invention relates to a method of, and apparatus for, selectively providing different paths for transmission of electric signals from one circuit to another. More specifically, the invention deals with a novel one-hand, finger-pressure actuation method of, and apparatus for, selective connection of a plurality of input means such as terminals to a plurality of output means such as terminals. The invention is believed to be best applicable to a digital mixer, although no unnecessary limitations to this particular application are intended.

[0002]

In analog mixers, which were in widespread use before the advent of digital counterparts, the input terminals are incorporated with a module for processing the input signals. What is known as a patch bay is used for selective manual connection of the input terminals to the signal processing module. The patch bay, also known as patch board, is a board or panel having a multiplicity of jacks at which circuits are terminated. Patch cables are plugged into the jacks to provide temporary signal paths. The patch cables are cumbersome of handling, and the poor or wrong contact, or even noncontact at all, of the plugs and jacks has been very liable to occur.

[0003]

These inconveniences are absent from digital mixers which dispense with patch cables by incorporating a microprocessor or a digital signal processor for signal path selection, as disclosed for example by Japanese Unexamined Patent Publication No. 11-215078. As heretofore constructed, however, digital mixers have not necessarily been easy of

manipulation because of complex manipulative steps involved which, moreover, are totally different from the handling of patch cables on analog mixers. Another objection to the prior art digital mixers is the inadequacy of measures taken to enable the operator to visually observe the signal paths he or she is making, which has added to the difficulty of manipulation of these mixers.

SUMMARY OF THE INVENTION

[0004]

The present invention has it as an object to defeat all the noted drawbacks of the prior art and to simplify and expedite the process of signal path selection in digital mixers or the like.

[0005]

Briefly stated in one aspect thereof, the invention may be summarized as a method of selectively providing desired electric signal paths between a plurality of input means such as input terminals and a plurality of output means such as output terminals. The method comprises providing input select means and output select means capable of manual actuation for selecting any of a plurality of input means and any of a plurality of output means for creation of a signal path therebetween. The input select means and the output select means are constantly monitored to determine whether any of the input means and any of the output means are selected for creation of a signal path therebetween. Then, upon determination of the selection of any one input means and any one output means for creation of a signal path therebetween, a preexisting signal path, if any, between the selected input means and any unselected output means and between any unselected input means and the selected output means is canceled. Then is created the desired signal path between the selected input means and the selected output means.

[0006]

Another aspect of the invention concerns a signal path selector for carrying the above summarized method into practice. It comprises a plurality of input means, a plurality of output means, input select means capable of manual actuation for selecting any of the input means for creation of a signal path to any selected output means, and output select means ca-

pable of manual actuation for selecting any of the output means for creation of a signal path from any selected input means. Also included are control means responsive to the actuation of the input select means and the output select means for creating the desired signal path between any selected input means and any selected output means to the exclusion of any preexisting signal path between the input means and the output means that might interfere with the creation of the desired signal path.

[0007]

In the preferred embodiments of the invention to be set forth subsequently, both input select means and output select means take the form of pushbutton switches. All that the operator needs to do for creation of a desired signal path is to depress one input select pushbutton and one output select pushbutton. The desired signal path will then be created automatically to the exclusion of any preexisting interfering path.

[0008]

Preferably, any one input select pushbutton and any one output select pushbutton are actuated simultaneously, as with the thumb and forefinger of one hand, rather than one after the other, for commanding a creation of a signal path therebetween. The simultaneous depression can then be utilized as additional information for specifying any desired signal path, reducing the manipulative steps required to that end. As an additional advantage, the one-hand, finger-pressure actuation of the pushbuttons is somewhat similar to the conventional patch cable connection of analog mixer terminals, so that the operator will readily get used to such manipulation of the pushbuttons according to the invention.

[0009]

It is also recommended that some form of visual indicator means be provided for indicating which of the input means and which of the output means are selected by the input select means and the output select means for creation of a signal path therebetween. Light-emitting diodes are preferred examples of such visual indicator means. One LED may be positioned adjacent each input means and each output means. When one input means and one output means are concurrently chosen for connection, the two associated LEDs may be lit up under the direction of the control means, enabling the operator to visually confirm his or her choices. Such visual indicators are believed to materially facilitate the selective connec-

tion of the input and output means.

[0010]

The above and other objects, features and advantages of this invention will become more apparent, and the invention itself will best be understood, from a study of the following description and appended claims, with reference had to the attached drawings showing the preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram explanatory of the first preferred embodiment of the invention, this embodiment being explanatory of the fundamental operating principles of the invention rather than representative of an actual working environment of the invention;

FIG. 2 is a plan view of explanatory nature showing the control panel of the signal path selector of **FIG. 1**;

FIG. 3 is a schematic electrical diagram, partly in block form, showing the **FIG. 1** signal path selector in more detail;

FIG. 4 is a diagram explanatory of the functions of the random-access memory included in the control means of the **FIG. 3** signal path selector;

FIG. 5 is a diagram similar to **FIG. 4** but showing the variables written RAM at one sampling moment in connecting one selected input terminal to one selected output terminal by the **FIG. 3** signal path selector;

FIG. 6 is also a diagram similar to **FIG. 4** but showing the variables written on the RAM at another sampling moment;

FIG. 7 is also a diagram similar to **FIG. 4** but showing the variables written on the RAM at still another sampling moment;

FIG. 8, consisting of (A) and (B), shows in block form some pertinent storage locations of the RAM in order to illustrate how a connection is made between one selected input terminal and one selected output terminal in the **FIG. 3** signal path selector;

FIG. 9, consisting of (A) and (B), is a diagram similar to **FIG. 8** but explanatory of how a preexisting connection is cancelled;

FIGS. 10 and **11,** each consisting of (A) and (B), are also diagrams similar to **FIG. 8** but explanatory of how a connection is made between

one selected input terminal and one selected output terminal to the exclusion of a preexisting interfering connection;

FIG. 12 is a flowchart of the connection control program introduced into the **FIG. 3** signal path selector;

FIGS. 13A, 13B and **13C** constitute in combination a flowchart of a subroutine of the **FIG. 12** connection control program;

FIG. 14 is a view similar to **FIG. 3** but showing the invention as applied to a digital mixer; and

FIG. 15 is a view similar to **FIG. 2** but showing the control panel of the **FIG. 14** digital mixer.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0011]

The present invention may be practiced in its simplest form as depicted in **FIG. 1**, showing a first circuit 1, a second circuit 2, and a signal path selector 3 constituting the gist of the invention. Connected between the circuits 1 and 2, the signal path selector 3 functions to selectively provide different signal paths therebetween. An example of the first circuit 1 is some source of multichannel analog audio signals, which is shown as having two output terminals 4*a* and 4*b* for putting out such signals. The second circuit 2 may then take the form of a multichannel recorder, complete with two analog input terminals 5*a* and 5*b*.

[0012]

The signal path selector 3 is what may be termed a digital path bay, shown as having two input terminals 6*a* and 6*b* and two output terminals 7*a* and 7*b* for ease of disclosure and understanding. Of course, in practice, much greater numbers of such terminals may be provided. The signal path selector 3 is equipped, as will be subsequently disclosed with reference to the other drawings, for connection of the first input terminal 6*a*, and of the second input terminal 6*b*, exclusively to either of the output terminals 7*a* and 7*b*. It is envisaged within the broader scope of the invention that the signal path selector 3 be constructed either simply for selective signal transfer from input terminals 6*a* and 6*b* to output terminals 7*a* and 7*b*, or, despite its broad naming here, equipped to give mixing, equalization, or other special effects to the incoming signals.

[0013]

The signal path selector 3 has a control panel shown in **FIG. 2** and therein generally designated 8. In conformity with the two input terminals 6*a* and 6*b* and two output terminals 7*a* and 7*b*, the control panel 8 is shown to have two input select pushbuttons 9*a* and 9*b*, together with input select indicators 10*a* and 10*b*, and two output select pushbuttons 11*a* and 11*b* with output select indicators 12*a* and 12*b*. All the pushbuttons 9*a*, 9*b*, 11*a* and 11*b* constitute actuator parts of electric switches to be disclosed subsequently. Typically, the indicators 10*a*, 10*b*, 12*a* and 12*b* take the form of light-emitting diodes, glowing upon depression of the associated pushbuttons to help the operator visually confirm the connections he has made.

[0014]

It will also be observed from **FIG. 2** that the first input terminal 6*a*, first input select pushbutton 9*a* and first input select indicator 10*a* are positioned closer to one another than to any other such parts on the control panel 8. The second input terminal 6*b*, second input select pushbutton 9*b* and second input select indicator 10*b* are also positioned closer to one another than to any other such parts on the control panel 8. Likewise, the first output terminal 7*a*, first output select pushbutton 11*a* and first output select indicator 12*a* are positioned closer to one another than to any other such parts on the control panel 8. The second output terminal 7*b*, second output select pushbutton 11*b* and second output select indicator 12*b* are also positioned closer to one another than to any other such parts on the control panel 8. Further, as additional visual aids to manipulation of the control panel 8, the indicia "INPUT I," "INPUT II," "OUTPUT I," and "OUTPUT II," are marked next to the terminals, pushbuttons and indicators of the respective groups.

[0015]

Hereinafter in this specification the term "object" will be used, where necessary, to refer to each group of terminals, pushbuttons and indicators on the control panel 8 with a view to the ease of disclosure and understanding of the invention. The first input terminal 6*a*, first input select pushbutton 9*a* and first input select indicator 10*a* constitute the first input object named "INPUT I". The second input terminal 6*b*, second input select pushbutton 9*b* and second input select indicator 10*b* constitute

the second input object with the name "INPUT II". The first output terminal 7*a*, first output select pushbutton 11*a* and first output select indicator 12*a* constitute the first output object with the name "OUTPUT I". The second output terminal 7*b*, second output select pushbutton 11*b* and second output select indicator 12*b* constitute the second output object with the name "OUTPUT II".

[0016]

Reference may be had to **FIG. 3** for a closer study of the signal path selector 1. It comprises, in addition to the means shown in **FIG. 2**, an analog-to-digital converter (ADC) 13, a preprogrammed read-only memory (ROM) 14, a random-access memory (RAM) 15, a digital signal processor (DSP) 16, a digital-to-analog converter (DAC) 17, and a bus 18. Having inputs connected to both first and second input terminals 6*a* and 6*b*, the ADC 13 digitizes the incoming analog audio signals for delivery to the DSP 16 over the bus 18.

[0017]

The reference numeral 19 generally denotes the control means of the signal path selector 1 comprising the ROM 14, RAM 15 and DSP 16, which are all connected to the bus 18. The control means 19 control the process of signal path selection in response to the actuation of the input select pushbuttons 9*a* and 9*b* and output select pushbuttons 11*a* and 11*b*. In practice the control means 19 may take the form of a microcomputer with a central processor unit.

[0018]

The functions of the control means 19 may be summarized and enumerated as follows:

1. To recognize the actuations of the input select pushbuttons 9*a* and 9*b* and output select pushbuttons 11*a* and 11*b* and how a signal path or paths are currently formed between the input terminals 6*a* and 6*b* and the output terminals 7*a* and 7*b,* that is, between INPUTS I and II and OUTPUTS I and II.

2. To determine the presence or absence of a preexisting connection or connections that might interfere with the creation of each desired new signal path from either of INPUT I and INPUT II, as specified by either of the input select pushbuttons 9*a* and 9*b*, to either of OUTPUT I and OUTPUT II as specified by either of the output select pushbuttons 11*a* and

11*b*, and, if there is any such potentially interfering preexisting connection, to cancel it.

3. To provide the desired signal path between the desired input object and the desired output object.

[0019]

The DAC 17 inputs the digital signals sent from the DSP 16 over the bus 18. The analog equivalents of these digital signals are sent to the multichannel recorder 2, **FIG. 1**, or the like via the output terminals 7*a* and 7*b*.

[0020]

As indicated also in **FIG. 3**, the input select pushbuttons 9*a* and 9*b* constitute the actuators of input select switches 21 and 22, respectively, whereas the output select pushbuttons 11*a* and 12*b* constitute the actuators of output select switches 23 and 24, respectively. All these switches 21-24 are connected to a supply terminal 29 via respective resistors 25-28 on the one hand and grounded on the other. The junctions between the switches 21-24 and the resistors 25-28 are all connected to the DSP 16 by way of the bus 18. Thus, when any of the switches 21-24 is actuated, the DSP is notified to that effect, and the information is stored on the RAM 15. It is understood that the DSP 16 conventionally operates at successive sampling moments.

[0021]

In use of this signal path selector 3 the operator is to choose a desired signal path by concurrently pressing either of the input select pushbuttons 9*a* and 9*b* and either of the output select pushbuttons 11*a* and 11*b*. Such concurrent depression of two pushbuttons is possible by use of the thumb and forefinger of either hand, which is reminiscent of the handling of patch cables on the patch bay of the conventional analog mixer. An operator accustomed to the patch bay will readily get used to such manipulation of the pushbuttons on the digital signal path selector according to this invention.

[0022]

Any desired combination of the input select pushbuttons 9*a* and 9*b* and output select pushbuttons 11*a* an 11*b* may simply be pressed concurrently for creation of a new signal path in cancellation of a preexisting one. Let it be supposed for instance that the first input select pushbutton 9*a* and

second output select pushbutton 11*b* are pressed simultaneously, when a signal path preexists between first input terminal 6*a* and first output terminal 7*a*. This preexisting signal path will be cancelled automatically, and the desired path established instead between first input terminal 6*a* and second output terminal 7*b*.

[0023]

It will also be observed from **FIG. 3** that the input select indicators 10*a* and 10*b* and output select indicators 12*a* and 12*b* are all connected via respective driver circuits 30-33 to the bus 18 thereby to be connected to the DSP 16. These LED indicators can therefore be selectively made to glow in response to signals from the DSP 16 upon actuation of the associated pushbuttons. The operator can visually confirm that he or she has interconnected the first input terminal 6*a* and first output terminal 7*a* if the indicators 10*a* and 12*a* are both lit up.

[0024]

FIG. 4 diagrammatically illustrates the constitution of the RAM 15. Functionally speaking, the RAM 15 contains:

1. A current pushbutton status table 41 for storing data indicative of whether the pushbuttons 9*a*, 9*b*, 11*a* an 11*b* are depressed or not at the current sampling moment.

2. A previous pushbutton status table 42 for storing data indicative of whether the pushbuttons 9*a*, 9*b*, 11*a* and 11*b* were depressed or not at the preceding sampling moment.

3. An input object name region C_1 for storing an object name when a corresponding one of the input select pushbuttons 9*a* and 9*b* is depressed.

4. An output object name region C_2 for storing an object name when a corresponding one of the output select pushbuttons 11*a* and 11*b* is depressed.

5. A first destination object region D_1 for storing the object name to which is to be connected the INPUT I objects.

6. A second destination object region D_2 for storing the object name to which is to be connected the INPUT II objects.

[0025]

More specifically, the current pushbutton status table 41 is constituted of two input select pushbutton status regions A_1 and A_2 and two out-

put select pushbutton status regions B_1 and B_2 for storing data indicative of the statuses of the input select pushbuttons 9*a* and 9*b* and output select pushbuttons 11*a* and 11*b*, respectively, at the current sampling moment. The previous pushbutton status table 42 is likewise constituted of two input select pushbutton status regions A_1' and A_2' and two output select pushbutton status regions B_1' and B_2' for storing data indicative of the statuses of the input select pushbuttons 9*a* and 9*b* and output select pushbuttons 11*a* and 11*b*, respectively, at the previous sampling moment.

[0026]

With reference back to **FIG. 3** the signal path selector 3 according to the invention is a digital device composed principally of the DSP 16. This DSP is designed for execution of the program that is factory introduced into the ROM 14. The program includes a routine for checking the pushbuttons 9*a*, 9*b*, 11*a* and 11*b* one by one to see if they are depressed at each sampling moment, and another routine for copying the contents of the current pushbutton status table 41 to the previous pushbutton status table 42 prior to such checking. If any of the pushbuttons is found depressed as a result of their sequential checking, the digit "1" is written on the corresponding region or regions of the current pushbutton status table 41, and the digit "0" on the other regions of the table.

[0027]

Following the checking of all the pushbuttons 9*a*, 9*b*, 11*a* and 11*b*, the current and previous pushbutton status tables 41 and 42 are compared to see any change in pushbutton status from one sampling moment to the next. A preexisting signal path or paths are maintained if no change is found. If a change is found with any pushbutton, on the other hand, then all the object names associated with this pushbutton are enumerated, and the following steps are taken:

1. To determine the direction in which the pushbutton has changed, that is, either from "off" to "on," or from "on" to "off."

2. To ascertain if either of the input select pushbuttons 9*a* and 9*b* and either of the output select pushbuttons 11*a* and 11*b* are depressed concurrently, and, if so, to create a signal path therebetween.

[0028]

Let us suppose that the operator wished to connect the first input terminal 6*a* to the first output terminal 7*a* and tried to press the first input

select pushbutton 9*a* and first output select pushbutton 11*a* at the same time, but that, actually, he or she actuated the first input select pushbutton first and then both first input and first output select pushbuttons concurrently. **FIGS. 5-7** are explanatory of what happens to the RAM 15 in the case assumed above.

[0029]

FIG. 5 shows what happens to the RAM 15 in response to the actuation of the first input select pushbutton 9*a* at a certain sampling moment. The digit "1" is written at the first input select pushbutton status region A_1 of the current pushbutton status table 41. Further the object name "INPUT I," to which belongs the first input select pushbutton 9*a*, is stored at the input object name region C_1. Still further the first input select indicator 10*a* will glow thereby visually indicating the operator choice of INPUT I.

[0030]

In **FIG. 6** is shown the status of the RAM 15 at the sampling moment following that of **FIG. 5**. This figure presupposes that no pushbuttons have been actuated since the moment of **FIG. 5**, so that the contents of the current pushbutton status table 41 in **FIG. 5** are shown copied on the previous pushbutton status table 42 in **FIG. 6**. The tables 41 and 42 are therefore the same in contents.

[0031]

At the next sampling moment, when both first input select pushbutton 9*a* and first output select pushbutton 11*a* are depressed concurrently, the RAM 15 will be in the state of **FIG. 7**. The digit "1" is shown stored at both first input select pushbutton status region A_1 and first output select pushbutton status region B_1 of the current pushbutton status table 41. Now a change has occurred between the first output select pushbutton status regions B_1 and B_1' of the current pushbutton status table 41 and the previous pushbutton status table 42, so that the object name "OUTPUT I" is shown stored at the output object name region C_2. The first output select indicator 12*a* is lit up.

[0032]

In **FIG. 7**, therefore, the object name "INPUT I" is shown stored at the input object name region C_1, and the object name "OUTPUT I" at the output object name region C_2. The next step is to refer this combination

of objects to the table, not shown, on the ROM 14 listing all the effective combinations of the objects, in order to ascertain if the combination now under consideration is among them. No combination of two inputs, or two outputs, is effective, so that no further step is taken. No further step is taken, either, when three or more pushbuttons are actuated simultaneously. The combination in question, INPUT 1 and OUTPUT I, is effective. The object name "OUTPUT I" is therefore written at the first destination object region D_1, as in **FIG. 7**, as the desired object to which INPUT I is to be connected.

[0033]

Possibly, any of the pushbutton switches may be opened when its object name is stored at the input object name region C_1 or the output object name region C_2. That object name is then erased. No response is made when any pushbutton switch is opened whose object name is stored at both input object name region C_1 and output object name region C_2.

[0034]

How the two inputs and the two outputs are variously interconnected, and the interconnections cancelled, according to the invention will become better understood from a study of **FIGS. 8-11.** The top row in each of these figures, designated (A), represents the initial states of the input object name region C_1, output object name region C_2, first destination object region D_1 and second destination object region D_2, whereas the bottom row (B) represents their final states indicative of the connections established.

[0035]

At (A) in **FIG. 8** it is supposed that the operator has actuated both first input select pushbutton 9*a* and first output select pushbutton 11*a* to connect INPUT I to OUTPUT I, with the result that the object name "INPUT I" is stored at the input object name region C_1, and the object name "OUTPUT I" at the output object name region C_2. The DSP 16, **FIG. 3**, will then check the first destination object region D_1 to see if INPUT I is already connected to either of OUTPUT I and OUTPUT II. The digit "0" shown stored at the first destination object region D_1 at (A) in **FIG. 8** indicates that the INPUT I is now connected to neither. Therefore, reading the object name "OUTPUT I" from the output object name region C_2, the DSP 16 proceeds to confirm the effectiveness of OUTPUT I

as a destination to which INPUT I is to be connected, and further to store that object name at the first destination object region D_1, as at (B) in **FIG. 8**. Now has been verified the connection of INPUT I and OUTPUT I.

[0036]

This desired connection of INPUT I and OUTPUT I must be exclusive; that is, if INPUT II has already been connected to OUTPUT I, this preexisting connection must be excluded preparatory to the connection of INPUT I and OUTPUT I. The DSP 16 checks the second destination object region D_2 for establishment of such exclusive connection. The second destination object region D_2 is shown to be "0" at (A) in **FIG. 8**, meaning that INPUT II is not connected to OUTPUT I, so that it is shown remaining "0" at (B) in **FIG. 8** too. If, contrary to the showing of **FIG. 8**, OUTPUT 1 were stored at the second destination object region D_2, the digit "1" would be erased, and "0" written in its stead. Further, if OUTPUT II were stored at the second destination object region D_2, meaning the preexistence of a connection between INPUT II and OUTPUT II, this connection would not interfere with the desired connection of INPUT I and OUTPUT I. The second destination object region D_2 would be left unchanged.

[0037]

FIG. 9 is explanatory of how a preexisting connection is broken up. At (A) in this figure are shown the RAM regions C_1, C_2, D_1 and D_2 in the same states as at (B) in **FIG. 8**, indicating the preexisting connection between INPUT I and OUTPUT I. If now the first input select pushbutton 9*a* and first output select pushbutton 11*a* are operated simultaneously, OUTPUT I will be erased from the first destination objection region D_1, and the digit "0" written in its stead, as at (B) in **FIG. 9**. The digit "0" at the region D_1 means that INPUT I is connected to neither output. In short any preexisting connection is cancelled by actuation of the same pushbuttons as when that connection was made. It is believed that the operator will readily get used to this method of cancellation of preexisting connections.

[0038]

A consideration of **FIGS. 10** and **11** will make clear how each new connection is established to the exclusion of any preexisting interfering connection. **FIG. 10** shows at (A) that a connection preexists between

INPUT I and OUTPUT II, as indicated by the object name "OUTPUT II" stored at the first destination object region D_1. If now the first input select pushbutton 9*a* and the first output select pushbutton 11*a* are depressed simultaneously, the object name "INPUT I" will be stored at the input object name region C_1, and "OUTPUT I" at the output object name region C_2, as at (B) in **FIG. 10**. At the same time, as indicated also at (B) in **FIG. 10**, the object name "OUTPUT I" will be overwritten on the preexisting object name "OUTPUT II" at the first destination object region D_1 as the object to which INPUT I is to be connected.

[0039]

Then the second destination object region D_2 is checked to see if OUTPUT I is stored there. The digit "0" shown at D_2 in **FIG. 10** indicates that OUTPUT I is not stored there, meaning that no interfering connection preexists between INPUT II and OUTPUT I. However, if OUTPUT I is stored at D_2 as at (A) in **FIG. 11**, there is a preexisting interfering connection between INPUT II and OUTPUT I. Then this preexisting connection is eliminated by writing "0" at D_2, as at (B) in **FIG. 11**, for creation of the desired new connection between INPUT I and OUTPUT 1.

[0040]

The DSP 16 of the signal path selector 3 is preprogrammed to comply with the indications of the destination object regions D_1 and D_2 of the RAM 15 for connecting each of INPUT I and INPUT II to either of OUTPUT I and OUTPUT II.

[0041]

Furthermore, in step with such manipulation of the pushbuttons, the DSP 16 causes the input select indicators 10*a* and 10*b* and output select indicators 12*a* and 12*b* to glow as visual aids to the creation of desired connections, as will be apparent from a consideration of **FIG. 3**. These indicators are to glow as dictated by the object names written at the input object name region C_1 and output object name region C_2. In the case shown at (A) in **FIG. 8**, for instance, the first input select indicator 10*a* and first output select indicator 12*a* are to glow inconformity with INPUT I stored at the input object name region C_1 and OUTPUT I stored at the output object name region C_2. The indicators 10*a*, 10*b*, 12*a* and 12*b* may glow either only while the associated pushbuttons are being depressed, or

until alternative pushbuttons are actuated. As desired, moreover, those indicators may be made to blink which correspond to the objects between which connections have been established.

[0042]

The reader's attention is now invited to the flowchart of **FIG. 12** for a study of the connection control program of the signal path selector 3. The main connection control program is designed in support of the above discussed method of providing connections between input terminals 6*a* and 6*b* and output terminals 7*a* and 7*b*. The RAM 15 and DSP 16, **FIG. 3**, are both initialized as the program is invoked at S_0. Initially, no signal path exists between input terminals 6*a* and 5*b* and output terminals 7*a* and 7*b*. It is understood that the pushbutton switches 21-24 are scanned periodically to determine whether they are open or closed. Either the sampling pulses used for data transfer, or those from a dedicated source of such pulses, may be utilized for the periodic scanning of the pushbutton switches.

[0043]

It is asked at the node S_1 of the connection control program whether a change has occurred to each of the pushbutton switches 21-24. This question is answerable by comparison of the current pushbutton status table 41, **FIG. 4**, and the previous pushbutton status table 42. As has been stated, these tables 41 and 42 indicate the statuses of the input and output select pushbutton switches 21-24 at the current and preceding sampling moments, respectively. If a change is found in any one or more of the pushbutton switches, the associated object name or names are written at the variables region or regions of the RAM 15. The object name or names are first temporarily listed on the RAM 15 according to the block S_2.

[0044]

Then, as dictated by the next block S_3, the listed object name or names are processed as variables for storage at the input select pushbutton status regions A_1 and A_2 and output select pushbutton status regions B_1 and B_2 of the current pushbutton status table 41, the input select pushbutton status regions A_1' and A_2' and output select pushbutton status regions B_1' and B_2' of the previous pushbutton status table 42, the input object name region C_1, the output object name region C_2, the first destination object re-

gion D_1, and the second destination object region D_2 of the RAM 15. More will be said presently about such variables with reference to **FIGS. 13A-13C**. The variables now under consideration are stored on the destination object regions D_1 and D_2 as in **FIGS. 8-11**. The object names temporarily listed as above on the RAM 15 are erased upon storage of the variables on the regions D_1 and D_2.

[0045]

Now that the desired connections between input terminals 6*a* and 6*b* and output terminals 7*a* and 7*b* have been confirmed, any required ones of the indicators 10*a*, 10*b*, 12*a* an 12*b* are lit up according to the block S_4.

[0046]

Then comes the final block S_5 which dictates signal transfer. If now the first input terminal 6*a* and the first output terminal 7*a* are interconnected, the analog audio signal incoming through the first input terminal 6*a* will be digitized by the ADC 13, then directed into the DAC 17 thereby to be reconverted into analog format, and then put out from the first output terminal 7*a*.

[0047]

FIGS. 13A-13C show in combination the subroutine to be executed at the block S_3 of the **FIG. 12** connection control program. The subroutine starts with the node S_{31}, **FIG. 13A,** which asks whether any pushbutton switch that has been found to have changed in state at the node S_1, **FIG. 12**, is now closed. If the answer is "no," that is, if the switch is now open, it means that the pushbutton has been actuated out of engagement with the fixed contacts of that switch. In this case only the input object name region C_1 and output object name region C_2 are rewritten as required. The answer "no" to the node S_{31} leads therefore to another node S_{32}, which asks if the input object name region C_1 stores the name of the object to which belongs the pushbutton switch that is now assumed to have been opened. If it does, that object name is erased from the input object name region C_1 at the block S_{33}. Then the subroutine returns to the node S_{31}.

[0048]

If the answer to the node S_{32} is "no," on the other hand, then it is ascertained at the block S_{34} if the output object name region C_2 stores the name of the object to which belongs the pushbutton switch that is assumed

to have been opened as above. If the answer to this question is "yes," the currently stored object name is erased at the next step S_{35}, from which the subroutine returns to the node S_{31}. If the answer is "no," on the other hand, then presumably the pushbutton switch that has been opened was indicative of a wrong connection. In this case, therefore, the subroutine returns from node S_{34} directly to node S_{31}.

[0049]

The answer to the node S_{31} may be "yes," that is, the pushbutton switch in question may now be closed, with the pushbutton pressed down. Then it is ascertained at the next node S_{36}, **FIG. 13B**, if the input object name region C_1 is empty, or has the digit "0" written thereon. If it is, no pushbutton was depressed at the preceding sampling moment. The desired input object name at the current sampling moment is therefore written at the input object name region C_1 according to the block S_{37}. The subroutine returns from this block S_{37} to the node S_{31}.

[0050]

If the answer to the node S_{36} is "no," on the other hand, that is, if some object name has been written at the input object name region C_1, then it is ascertained at the next node S_{37a} if the output object name region C_2 is empty. If it is not, a wrong manipulation was presumably made, so that the subroutine returns from the node S_{37a} to the node S_{31}. If the output object name region C_2 is empty, on the other hand, then it is determined at the next node S_{38} whether the object name that has been stored at the input object name region C_1 makes a good combination with the object that has been just specified by depression of the associated pushbutton. The answer will be "no" if they are a bad combination of two input objects or of two output objects, with the result that the subroutine returns to the node S_{31}. If they are a good combination, on the other hand, then the object name just specified is written at the output object name region C_2 according to the block S_{39}.

[0051]

Now the subroutine proceeds to deal with the two destination object regions D_1 and D_2. First, according to the block S_{40}, the first destination object region D_1 is referred to, and the object name "INPUT I" is read out therefrom. Then, according to the following node S_{41}, **FIG. 13C**, it is ascertained if the object name stored at either of the input object name re-

gion C_1 and output object name region C_2 agrees with the object name stored at whichever of the destination object regions D_1 and D_2 now being referred to. For instance, it is ascertained if the input object name region C_1 now stores the object name "INPUT I" which is to be connected to the object whose name is stored at the destination object region D_1, as at (A) in all of **FIGS. 8-11.**

[0052]

If the answer to the node S_{41} is "no," it is subsequently determined according to the node S_{46} if the object name stored at the other of the input object name region C_1 and output object name region C_2 agrees with the object name stored at whichever of the destination object regions D_1 and D_2 now being referred to. The answer to the node S_{46} will be "yes" if, for instance the object name "OUTPUT I" is stored at both the output object name region C_2 and the second destination object region D_2 as at (A) in **FIG. 11**. Then the object name stored at the second destination object region D_2 is erased according to the block S_{47}. The digit "0" is written there instead, as at (B) in **FIG. 11**, thereby canceling the current connection. The subroutine returns from the block S_{46} directly to the block S_{45} if the answer to the former is "no."

[0053]

If the answer to the node S_{41} is "yes," on the other hand, then the next node S_{42} asks if the object name stored at the other of the input object name region C_1 and output object name region C_2 agrees with that stored at whichever of the destination object regions D_1 and D_2 now being referred to. The answer to the node S_{42} will be "no" if, as indicated at (A) in **FIG. 10** by way of example, the object names disagree between C_2 and D_1. Then, according to the block S_{44}, the desired new output object name (e.g., OUTPUT I) is overwritten at whichever of the destination object regions D_1 and D_2 now being referred to, as indicated at (B) in **FIG. 10**. The answer to the node S_{42} will be "yes" if the same object name is stored at both C_2 and D_1 as at (A) in **FIG. 9**. Then the object name is erased from whichever of the destination object regions D_1 and D_2 now being referred to, according to the block S_{43}, thereby nullifying the current connection.

[0054]

The subroutine proceeds from all of the blocks S_{43}, S_{44} and S_{47} as

well as the "no" output of the node S_{46} to the node S_{45}, which asks whether the last destination object region D_2 is being referred to. If it is not, then the object name of the destination object region D_2 is checked according to the next block S_{48}, from which the subroutine returns to the node S_{41}. If the answer to the node S_{45} is "yes," on the other hand, the subroutine returns to the block S_4, **FIG. 12**, of the connection control program.

[0055]

The advantages gained by this particular embodiment of the invention may be recapitulated as follows:

1. Any possible connections between input terminals 6*a* and 6*b* an output terminals 7*a* and 7*b* can be formed by simple depression of the input select pushbuttons 9*a* and 9*b* and output select pushbuttons 11*a* and 11*b*, without the risk of concurrently connecting either one input to two outputs.

2. One-to-one connection between inputs and outputs is assured as desired new object names are overwritten on preexisting ones.

3. The input select indicators 10*a* and 10*b* and output select indicators 12*a* and 12*b*, all preferably in the form of LEDs, are provided in close proximities of the input select pushbuttons 9*a* and 9*b* and output select pushbuttons 11*a* and 11*b*, respectively, enabling the operator to visually confirm the connections he has made.

4. The first input terminal 6*a*, first input select pushbutton 9*a* and first input select indicator 10*a*, all belonging to the object named "INPUT I", are positioned close to one another, and so are the second input terminal 6*b*, second input select pushbutton 9*b* and second input select indicator 10*b* of the object "INPUT II." Similarly, the first output terminal 7*a*, first output select pushbutton 11*a* and first output select indicator 12*a* of the object "OUTPUT I" are positioned close to one another, and so are the second output terminal 7*b*, second output select pushbutton 11*b* and second output select indicator 12*b* of the object "OUTPUT II." The operator is therefore enabled to know exactly what he or she is doing, just as he or she does when handling patch cables on a patch bay.

Alternate Embodiment

[0056]

The fundamental constructional and operational features of the instant invention are believed to be apparent from the foregoing embodiment of the instant invention. Shown in **FIG. 14**, then, is the digital mixer that is representative of an actual device in which the invention may be embodied in practice. Generally designated 3*a*, the digital mixer is shown to have four analog input terminals 6*a*-6*d* as a first group of objects, and four mixing modules 50*a*-50*d* as a second group of objects. The two groups of objects are to be selectively connected to one another according to the invention. The four input terminals 6*a*-6*d* are all connected via the ADC 13 to the bus 18, to which bus are also connected the mixing modules 50*a*-50*d*.

[0057]

As illustrated in **FIG. 15**, which shows the control panel 8*a* of the **FIG. 14** mixer 3*a*, the four input terminals 6*a*-6*d* are arranged in a row on the control panel. Under these input terminals 6*a*-6*d*, four input select pushbuttons 9*a*'-9*d*' and four input select indicators 10*a*'-10*d*' are disposed adjacent the respective input terminals 6*a*-6*d*. The pushbuttons 9*a*'-9*d*' and indicators 10*a*'-10*d*' perform the same functions as the pushbuttons 9*a* and 9*b* and indicators 10*a* and 10*b*, **FIG. 2,** of the previous embodiment.

[0058]

As indicated also in **FIG. 15**, the mixing modules 50*a*-50*b* are represented on the control panel 8*a* as having fader controls 51*a*-51*d*, panpots 52*a*-52*d*, gain controls 53*a*-53*d*, and equalizer indicators 54*a*-54*d*, respectively. All these mixing module components, shown enclosed in the broken-line rectangles and generally labeled 50*a*-50*d* for convenience, are disposed under the four input terminals 6*a*-6*d*, respectively.

[0059]

For selective connection of the input terminals 6*a*-6*d* to the mixing modules 50*a*-50*d*, there are provided four mixing module select pushbuttons 11*a*'-11*d*', complete with four mixing module select indicators 12*a*'-12*d*', each between one input terminal and one associated mixing module. The mixing module select pushbuttons 11*a*'-11*d*' are similar in

function to the output select pushbuttons 11*a* and 11*b*, **FIG. 2**, of the previous embodiment, and so are the mixing module select indicators 12*a*'-12*d*' to the output select indicators 12*a* and 12*b* of the previous embodiment.

[0060]

Despite the showing of **FIG. 15**, however, **FIG. 14** shows only the first two input select pushbuttons 9*a*' and 9*b*' with their switches 21 and 22, the first two input select indicators 10*a*' and 10*b*', the first two mixing module select pushbuttons 11*a*' and 11*b*' with their switches 23' an 24', and the first two mixing module select indicators 12*a*' and 12*b*'. The other two input select pushbuttons 9*c*' and 9*d*' and the other two mixing module select pushbuttons 11*c*' and 11*d*', which are shown in **FIG. 15**, are not in **FIG. 14** for lack of space.

[0061]

Also shown arranged on the **FIG. 15** control panel 8*a* are two master fader controls 55*a* an 55*b*, two maser fader select pushbuttons 56*a* and 56*b*, two master fader select indicators 57*a* and 57*b*, an effecter select pushbutton 58*a*, an effecter select indicator 58*b*, an equalizer select pushbutton 59*a*, and an equalizer select pushbutton 59*b*. The two output terminals 7*a* and 7*b* together with their select pushbuttons and indicators are also provided on the control panel 8*a* but now shown in **FIG. 15** for lack of space.

[0062]

The effecter 58 and equalizer 59 shown included in the DSP 16*a*, **FIG. 14**, for convenience can both serve only one channel at one time, so that the four input terminals 6*a*-6*d* are to be selectively connected thereto for use. The effecter 58 and equalizer 59 may be thought of as each having an input and an output for selective connection respectively to the four input terminals 6*a*-6*d* and to the four mixing modules 50*a*-50*d*. When these effecter and equalizer are to be so inserted, their input terminals form the output-side objects to which are to be selectively connected the input terminals 6*a*-6*d*, and their output terminals for the input-side objects to be selectively connected to the mixing modules 50*a*-50*d*.

[0063]

How such input- and output-side objects of this digital mixer 3*a* are selectively interconnected is considered self-evident from the foregoing

description of the **FIGS. 1-3** embodiment, with reference had to **FIGS. 4-13**. The ROM 14*a*, RAM 15*a* and DSP 16*a* of the **FIG. 16** digital mixer 3*a* are shown enclosed in the dashed outline as constituting the control means 19*a* for effecting such selective connection. No further operational description of the digital mixer 3*a* will therefore be necessary except for the following definitions of the objects for use in selective connection of mixer input terminals 6*a*-6*d* and mixing modules 50*a*-50*d*:

Input-side object "INPUT I":

First input terminal 6*a*, first input select pushbutton 9*a*', and first input select indicator 10*a*'.

Input-side object "INPUT II":

Second input terminal 6*b*, second input select pushbutton 9*b*', and second input select indicator 10*b*'.

Input-side object "INPUT III":

Third input terminal 6*c*, third input select pushbutton 9*c*', and third input select indicator 10*c*'.

Input-side object "INPUT IV":

Fourth input terminal 6*d*, fourth input select pushbutton 9*d*', and fourth input select indicator 10*d*'.

Output-side object "OUTPUT I":

First mixing module 50*a*, first mixing module select pushbutton 11*a*', and first mixing module select indicator 12*a*'.

Output-side object "OUTPUT II":

Second mixing module 50*b*, second mixing module select pushbutton 11*b*', and second mixing module select indicator 12*b*'.

Output-side object "OUTPUT III":

Third mixing module 50*c*, third mixing module select pushbutton 11*c*', and third mixing module select indicator 12*c*'.

Output-side object "OUTPUT IV":

Fourth mixing module 50*d*, fourth mixing module select pushbutton 11*d*', and fourth mixing module select indicator 12*d*'.

[0064]

It will also be appreciated that all these input-side objects, INPUT I,

INPUT II, INPUT III and INPUT IV, and output-side objects, OUTPUT I, OUTPUT II, OUTPUT III and OUTPUT IV, are selectively connected to each other to the exclusion of any preexisting interfering connection or connections therebetween. The same holds true with selective connection between the input terminals 6a-6c and the effecter 58 and equalizer 59 and between these effecter and equalizer and the mixing modules 50*a*-50*d*.

[0065]

Although the present invention has been shown and described hereinbefore in specific aspects thereof, first in its simplest, rather conceptual form and then in more practical form, it is not desired that the invention be limited by the exact details of such disclosure. A variety of modifications or alterations may be adopted in the practice of this invention in order to conform to design preferences or to the requirements of each specific application. For instance, the concepts of the invention may be applied to selective connection between the master faders 55*a* and 55*b*, **FIG. 17**, and output terminals 7*a* and 7*b*, **FIG. 16**, of the digital mixer 3*a*. It is therefore appropriate that the invention be construed broadly and in a manner consistent with the fair meaning or proper scope of the subjoined claims.